TERRESTRIAL AIRBORNE HYPERSPECTRAL REMOTE SENSING (SEBASS): APPLICATIONS TO REMOTE SENSING OF MARS.
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Summary: The first stage in the Mars exploration program is to reconnoiter the planet from orbit using infrared remote sensing. The current approach relies heavily on the Global Surveyor Thermal Emission Spectrometer (TES, ~6.5-50 µm, 143 channels), and the 2001 Mars Odyssey 9-band radiometer THEMIS. Landing site selection and modeling of the climate history depend on accurate interpretations of these data sets. Interpretations are based on terrestrial analog remote sensing and laboratory studies. Current terrestrial analog remote sensing studies rely on multi-channel radiometer measurements (e.g. TIMS, MASTER), because there have been no airborne hyperspectral thermal emission data sets available. Here we report on unique hyperspectral images recorded by the Spatially Enhanced Broadband Array Spectrograph System (SEBASS, 7.6-13.5 µm, 128 channels), and the relevance to remote sensing studies of Mars.

Background: TES measures over the ~6.5-50 µm range in 143 channels, with a spectral resolution of 10 or 20 cm^{-1}. Terrestrial atmospheric water vapor and CO_2 limit the terrestrial atmospheric window over the TES range to ~7.5-13.5 µm. We desire to have a terrestrial data analog for TES over the 7.5-13.5 µm range in order to improve understanding of the remotely sensed spectra TES records.

Past TES analogs had to rely on low spectral resolution radiometer studies, such as the Thermal Infrared Multispectral Scanner (TIMS), which measures 6 broad bands over the 8-14 µm region; or MASTER, which has 10 bands. The advantage of these instruments is the lower data rate that results from fewer channels. However, low contrast spectral signatures recorded by radiometers lack characteristic spectral detail. In addition, since the ability to detect a spectral signature decreases with poorer spectral resolution, radiometers have reduced ability to detect, identify, and characterize weak spectral signatures. As a result, radiometer remote sensing studies typically rely on ground truth to obtain compositional information, and on laboratory spectra measured at higher spectral resolution to complete the analog to TES spectra.

Thus in TES terrestrial analog studies the gap that remains is remotely sensed measurements recorded with sufficient spectral resolution and signal-to-noise ratio (SNR) to allow a detailed examination of hyperspectral behavior as recorded in the field environment. SEBASS fills this gap by providing spectra measured with good spectral resolution and very high SNR.

Instrument: SEBASS provides a unique and unprecedented spectral analog for TES. SEBASS measures with the highest spectral resolution and SNR of any thermal infrared hyperspectral imaging spectrometer, and Figure 1 compares the SNR of TES and SEBASS.

SEBASS is a cooled prism spectrometer. It measures the two mid-infrared terrestrial transmission "windows" using two wavelength ranges: 4132-1876 cm^{-1} (2.42-5.33 µm) and 1321-740 cm^{-1} (7.57-13.52 µm). Each range is measured in 128 channels, with a spectral resolution of 7 cm^{-1} at 890 cm^{-1}, and a one milliradian field of view per pixel. SEBASS operates as a pushbroom instrument, using two 128 x 128 detector arrays, and the entire optical bench is cooled to 4K using liquid helium. It is operated by The Aerospace Corporation's Office of Spectral Applications, under the direction of John Hackwell. For TES analog studies we use the long wavelength SEBASS data. The hyperspectral images are typically 128 pixels wide and 2000 pixels long, measured with a surface spatial resolution of ~1 or 2 m^2.

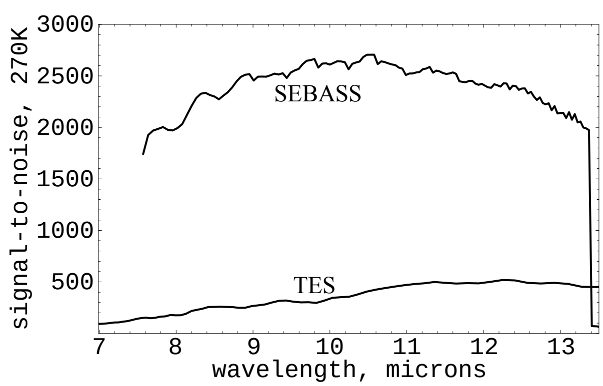

Figure 1: SEBASS and TES SNR. This shows the SEBASS and r.m.s. signal-to-noise ratio for a blackbody at 270K. Higher numbers indicate higher sensitivity.

Current data sets: We have recorded four SEBASS data sets with the goal of addressing several broad spectral questions that have strong implications for interpretations of TES and THEMIS data, and we will present results of these studies. Here we will describe the data sets and the questions they are designed to address.

First, is a data set recorded of the Mormon Mesa, Nevada, to examine the field spectral signature of carbonates. This study is detailed in [1].

Second, the Barringer Crater (Meteor Crater), Arizona. Two SEBASS images were recorded of the crater (Figure 1). The spectra can be used to examine the hyperspectral field signature exhibited by the layers visible in the crater walls (Figure 2), carbonates, and to search for differences between the field signatures of quartz and shocked quartz (stishovite).

Figure 2: These are the SEBASS images of the Barringer Crater.

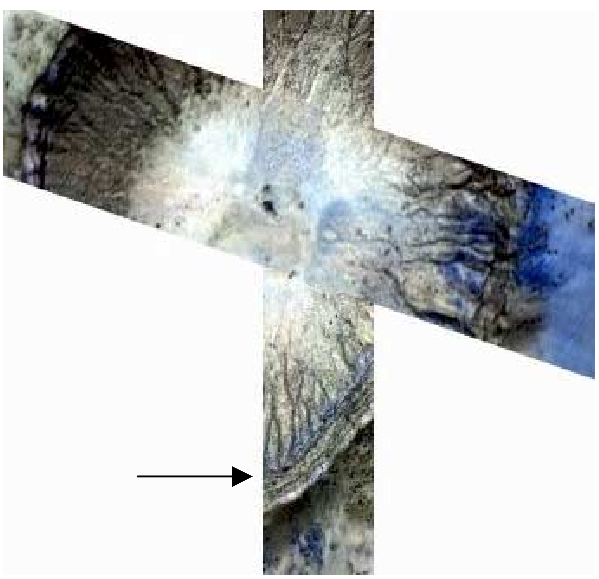

Figure 3: This shows a section of the SEBASS Barringer Crater hyperspectral images (Figure 2). Note the layering evident in the SEBASS data (arrow).

Third, the Sunset Crater, Arizona, which contains relatively high iron content, vesicular olivine-basalts, and a range of weathering and surface textures.

Fourth, the SP Crater, Arizona, which has exposures of andesitic basalts. Preliminary examination of these spectra [2] led to the conclusion that it may be challenging to separate signatures exhibited by glassy cooling rinds, glassy materials, and desert varnish using the SEBASS range. Laboratory spectra indicate differentiating between these materials may be a challenge over the 2.5-25 µm range. Figure 3 shows a small section of one of the SEBASS SP Crater images.

We will show results from these data sets; discuss implications for remote sensing studies of Mars; and discuss what the results indicate for what is most needed in terrestrial analog studies to assist interpretations of TES and THEMIS data.

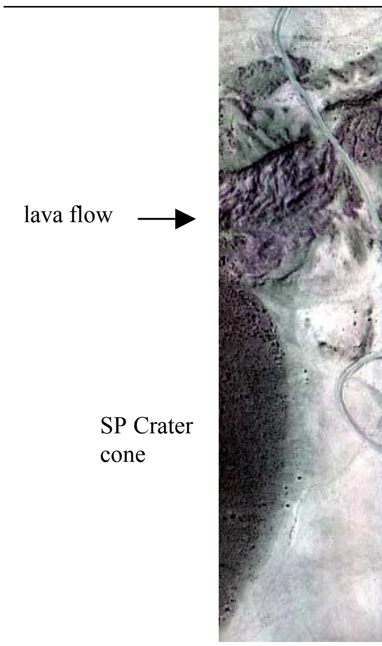

Figure 4: SEBASS data of SP Crater. The linear and sinuous features are roads.

References: [1] Kirkland L. E. et al. (2000), submitted to *LPSC XXXII*. [2] Ward et al. (2000), submitted to *LPSC XXXII*.